FRD Activities Report
February 2001

Research Programs

CBLAST-Low

Existing parameterizations of heat, moisture, and momentum fluxes in the marine atmospheric boundary layer (MABL) perform poorly under weak wind regimes, especially in regions of inhomogeneity. These problems are due to a variety of processes including averaging techniques, gravity capillary wave spacing, surfactants and surface tension, free convection effects, and frequency-dependent differences between wind, waves, and stress. In order to address these various forcing mechanisms, high-resolution, high-fidelity atmospheric and surface wave data are needed to describe energy exchange across the air-sea interface. The LongEZ research aircraft will be an integral part of the upcoming Coupled Boundary Layer Air-Sea Transfer (CBLAST) light-wind research study which will be conducted in Martha's Vineyard, Massachusetts, from July 20 to August 10, 2001. These data will support the test and refinement of parameterizations used in air-sea models. In addition, such measurements provide important boundary conditions to determine boundary layer turbulence and other atmospheric processes controlling the exchange of energy across the air-sea interface.

Below are brief summaries of the progress made over the last month on hardware and software modifications of the mobile flux platform carried by the LongEZ.

<u>Sea Surface Temperature (SST) Sensors</u>

Drifts in sea surface temperature (SST) data acquired by an Everest 4000.4GXL infrared temperature sensor has been linked to changes in the body temperature of the instrument. This was first suspected during the Shoaling Waves Experiment (SHOWEX) when ambient air temperatures (thus sensor body temperature) were near freezing in the morning at the start of a flight and up to 20 °C by late morning to early afternoon when the LongEZ completed its mission.

Two types of tests have been run to characterize sensor performance using a well-mixed water bath. The first test involved keeping the body temperature of the sensor at a (nearly) constant temperature while heating the water bath temperature from an ice/slush mix (0 °C) up to 40 °C. The second test kept the water bath at a constant temperature over time while allowing the sensor to slowly warm up to ambient temperature.

In Figure 1, a bath consisting of a well-mixed water/ice slush was continuously heated for about 40 min. The Everest body temperature remained nearly constant (24.1 ± 0.7 °C) over the course of the test. Body temperature of the infrared sensor was observed by attaching a thermocouple to the outside side wall. The sensor was then wrapped with insulation to maintain a uniform temperature. In this particular case, a linear fit from over the 40 °C temperature range is actually very good with a correlation coefficient of 0.9996 and an rms error of 0.16 °C. However, under closer inspection, there are four distinctive and discrete regimes where linear slope decreases with increasing temperature (red, 0.5 to 7 °C, slope = 1.24; green, 8 to 18 °C, slope = 1.14; blue, 20° to 33 °C, slope = 1.08, orange, 35 to 40 °C, slope = 1.02). Apparently, one of several internal calibration curves are used by the Everest sensor based on the target (water) temperature and an internal body temperature of the sensor. This test (constant body temperature, varying bath temperature) was conducted several times. These small but discrete changes in slope are repeatable. Upon further inspection, a second-order polynomial over the 40 °C temperature range is far superior than the a simple linear fit.

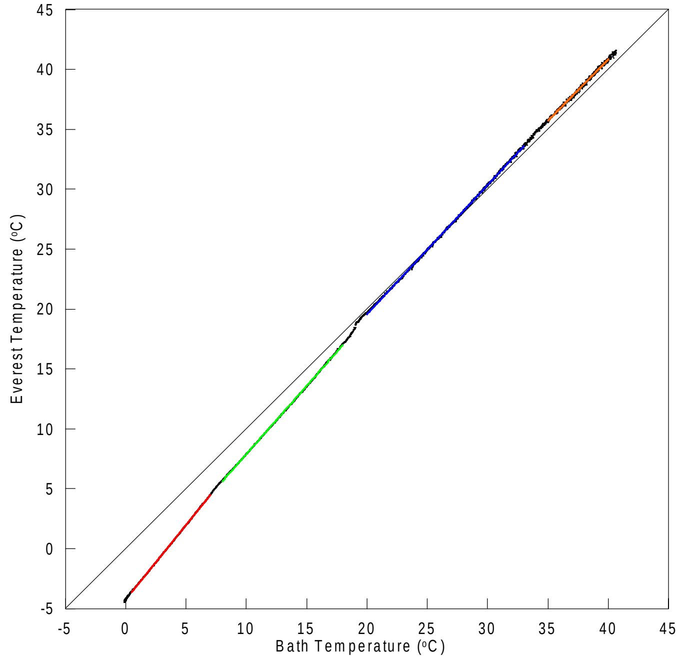

Figure 1. Scatter plot of Everest temperature versus bath temperature.

Figure 2 shows a time series of several temperatures. In this case, a well-mixed, nearly constant temperature bath (16.7 ± 0.1 °C) was maintained during this test which lasted about 3.5 hr. The Everest sensor was taken out of a freezer and allowed to slowly warm up to ambient temperature. The response of the sensor to these temperature changes was, to say the least, severe. Four unique regimes can be observed in this time series. For a body temperature between -10 to -7 °C, the Everest output temperature actually decreases with increasing body temperature. A second regime can be seen for body temperatures between -7 and 4 °C with a sharp, step-change in temperature at the high-end of that range. Two more regimes can been seen between body temperatures of 4 and 12 °C and 12 and 17 °C. Needless to say, even small deviations in sensor body temperature can significantly affect data reliability.

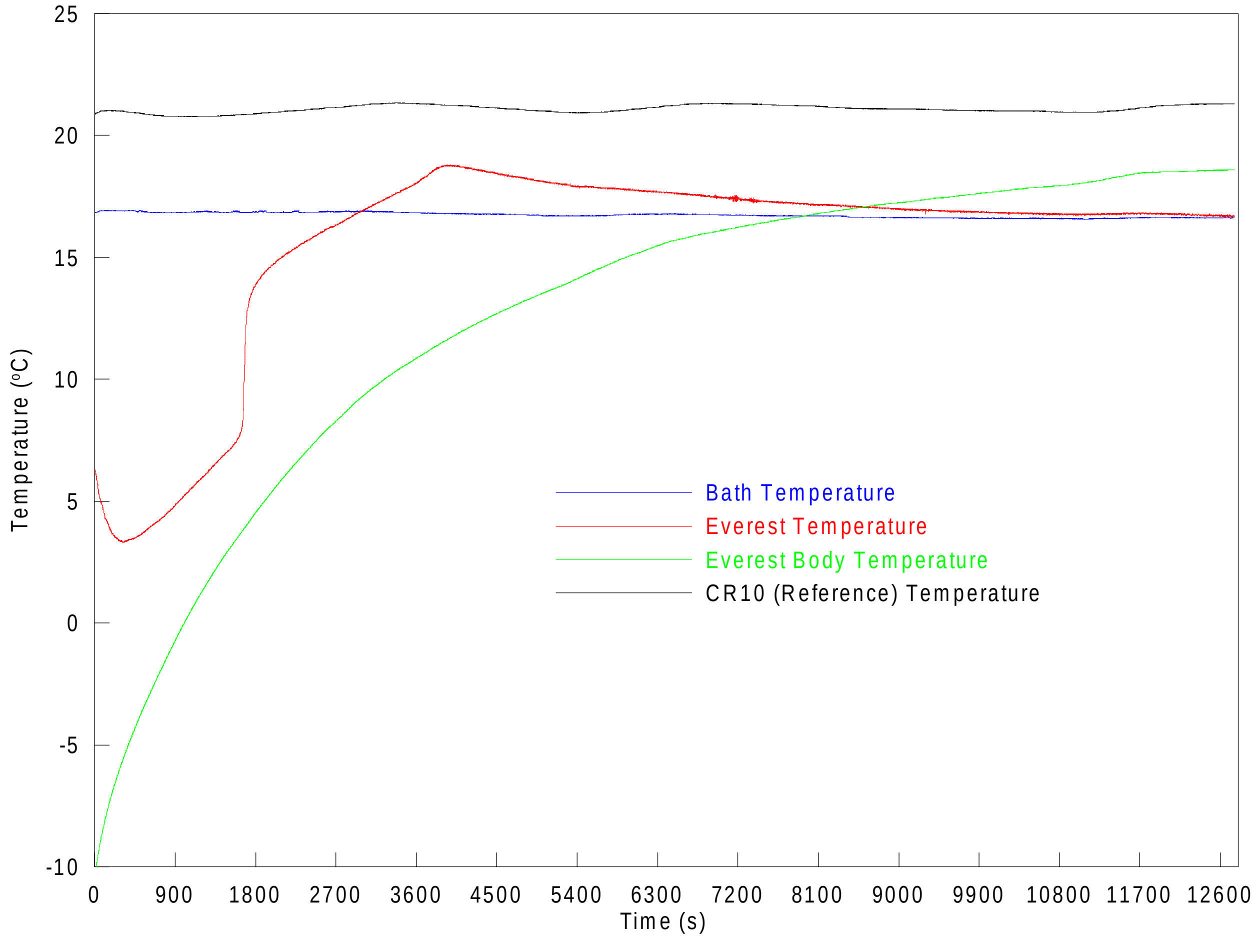

Figure 2. Time series of Everest, bath, body, and reference temperature.

An Apogee precision infrared thermocouple transducer was also tested an alternative sensor for SST measurement. The performance of the sensor during the constant body temperature, varying bath temperature test was exceptional. A linear regression yielded a nearly perfect correlation with an rms error of ~ 0.05 °C. However, the constant bath temperature, varying body temperature test yielded less than desired results with problems in temperature sensitivity. Another problem with this sensor is the rather slow time response (~ 1 s) compared to the fast time response of the Everest (~ 0.02 s). A sensor with a fast response time is needed to discern subtle changes in SST under light-wind regimes and high flight speeds.

In order to obtain even reasonable SST measurements, the Everest infrared sensor will have to be maintained at a constant temperature and a second order polynomial should be employed for calibration purposes over a range of up to 40 °C. We are considering adding the Apogee sensor to the sensor suite. The two time series may be spectrally blended (low-frequency signal from the Apogee and the high-frequency signal from the Everest) to create a high-accuracy, high-resolution time series of SST. (Jerry.Crescenti@noaa.gov)

Laser Array

A new high-speed (12-KHz) laser altimeter has been ordered from Riegl and will be incorporated into the existing triangular array of three 2-KHz lasers. This laser array has been used to quantify ocean surface wave features such as height, amplitude, and phase for wavelengths greater than 1 m. Laser #2 (Figure 3), which resides in the pod underneath the LongEZ will be replaced with the new high-speed laser. The older laser will then become Laser #4, which will also reside in the pod. However, unlike the three lasers which point vertically down to the surface, Laser #4 will be at an oblique angle from the vertical (15° to 30°). This laser will be useful in detecting roughness elements of the ocean surface under calm to very light-wind conditions. In addition, the sampling rate of the lasers will be increased from 50 to 150 Hz. This increase in sampling should allow the laser array to resolve smaller waves by a factor of three. (Jerry.Crescenti@noaa.gov)

Figure 3. Riegl laser altimeter.

Scatterometers

Along-track changes in the integrated roughness of short ocean waves on the order of 2 to 100 cm are determined using a nadir-pointing Ka-band (36-GHz or 0.8 cm) scatterometer developed and supported by Douglas C. Vandemark from NASA's Goddard Space Flight Center (http://rows.wff.nasa.gov/dls.html/). This sensor is used to infer the short wave characteristics by relating backscatter intensity to the surface slope variance. Coincident laser altimeter measurements provide the precise range information for computation of the normalized radar cross section. Recent analysis has also shown that the radar/laser combination leads to high fidelity observations of the long-wave, short-wave hydrodynamic modulation transfer function.

The nadir-viewing Ka-band scatterometer is a simple continuous wave (CW) system that has worked well in WAPEX and SHOWEX. Based on TOGA-COARE light wind studies, we expect this sensor to be useful in measuring meter to kilometer-scale short wave adjustments associated with the various ocean and atmospheric processes. This absolutely-calibrated system is now being repackaged for durability and ease of calibration for CBLAST-Low. This work includes miniaturization via use of microstrip antennas.

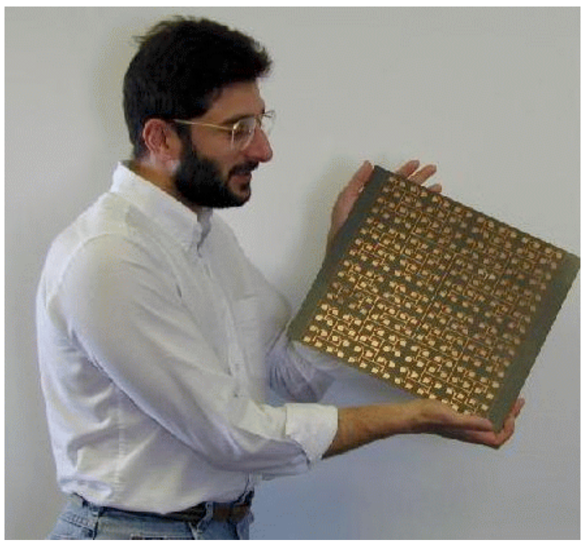

Figure 4. 30-cm microstrip antenna for the new Ku-band scatterometer.

We are now adding a Ku-band (96 GHz or 2.3

cm) nadir-viewing scatterometer that will operate alongside the Ka-band system expressly for support of the light wind observations (Figure 4). One anticipates a wave environment often characterized by 5- to 15-cm scale carrier waves having parasitic capillary waves governing their growth. Recent dual-frequency TOPEX altimeter satellite studies have shown that a C- and Ku-band nadir-viewing combination provides a useful tool for probing these characteristics at light wind speeds. We have procured a customized 30-cm microstrip antenna which will be mounted under the LongEZ fuselage just forward of the instrument pod. (Jerry.Crescenti@noaa.gov)

<u>FUST Probe</u>

The FRD-designed Fast, Ultra-Sensitive Temperature (FUST) probe is being incorporated into the BAT Probe. Like the already existing fast-response sensor on the BAT, the FUST provides measurements of fluctuations about some slowly varying mean temperature. Unlike the current sensor, however, the FUST will be able to provide useful measurements at rates up to the sampling frequency of the data system and will have a resolution of 0.01 C. This will drastically improve our ability to detect extremely small temperature perturbations in the light-wind conditions to be encountered in CBLAST-Low. (Jeff.French@noaa.gov, Randy Johnson)

CBLAST-Hurricane / CBLAST-low

Initial testing has begun for an upgraded data system for both the LongEZ platform and for the BAT/MFP system for the NOAA P3. Some upgrades include an industrial-type PC with back-plane utilizing a single-board computer and a re-designed Auxiliary BOX that will house the system power distribution, signal conditioning cards and one of the system's two BAT-REMs. The new system will utilize Flash memory (PCMCIA/ATA Type II) to record data on the fly. The new upgrades are necessary to be able to handle the increasing CPU/disk access demands resulting from new instruments with higher sampling frequencies and increased data rates. (Jeff.French@noaa.gov)

Model Validation Program (MVP)

Funding is now in place to analyze the Long-EZ data collected during the Air Force MVP experiment that took place at Vandenberg Air Force Base in California. Unfortunately, the data acquisition program used during this experiment had bugs that caused the GPS attitude angles to be scrambled in time. A close inspection of the data has uncovered some repeatable patterns that will allow at least some of the attitude data to be unscrambled. During the last few flights, the raw attitude data were dumped to a separate file. The data in these files are not scrambled, so these flights can be processed without problem. The raw attitude data dumps were not available in earlier flights, so there is likely to be gaps in the wind data for these flights. (Richard.Eckman@noaa.gov)

CASES-99

During the CASES-99 experiment in October 1999, the Long-EZ aircraft collected about 50 hours of data in stable conditions. Funding for the experiment was sufficient to put the Long-EZ into the field, but not for data processing and analysis. Additional FY 2001 funding is now becoming available through ATDD in Oak Ridge, so processing and analysis of the data is expected to begin in the near future. (Richard.Eckman@noaa.gov)

AFTAC (GAUNTLET) and Divine Umpire

We completed all preparations for Divine Umpire deployment by 23 February. These included supply procurement, personnel SF_6 analyzer training, SF_6 analyzer preparation and analyzer installation. We also prepared a hurricane balloon for marking the SF_6 puff as it moved with the wind. This latter item was prepared without cost to the Divine Umpire program. However, after we had nearly completed our preparations to deploy to Dugway with the balloon, the sponsor of DU would not permit tracking of the balloon by aircraft or even permit the balloon to fly during the test. We, therefore, ended our plans to deploy the balloon at Dugway. The date for SF_6 mobile analyzer deployment for DU began to slip, as determined by the main DU sponsor. The date continued to slip until 02 March, when we received word from our sponsor (who wanted us to conduct a piggyback on DU) that our participation in DU would be terminated due to their time constraints. We have stopped all work on DU and have turned our attention to GAUNTLET.

The preparations for GAUNTLET are nearly complete. The release mechanism has been refurbished and is ready for testing. It has also been made mobile, as the mechanism has been built onto a two-axle trailer. This will permit rapid redeployment of the mechanism together with Dugway's mobile stack, should meteorological conditions dictate such a move. The mobile analyzers have also been refurbished with new tritium detectors. The analyzers have been tested in the laboratory and are working well, with detection limits as low as background SF_6 levels.

Coordination efforts are continuing with Jimmy White of Dugway Proving Ground for the release of SF_6. It was discovered in January that Dugway's proposed release rate of 30 kg per hour would provide an insufficient amount of SF_6 for our analyzers to detect at distances of 50 km. The previous release rate of 75 kg per hour at the INEEL was barely sufficient to permit occasional detection of SF_6 to a distance of 50 km in the daylight hours. This issue needs to be resolved before we can test our release mechanism prior to deployment to Dugway in early March. (Kirk.Clawson@noaa.gov, Randy Johnson, and staff)

Preparations for the tracer experiments at Dugway Proving Ground this April are well underway. The TGA-4000 continuous SF_6 analyzers are operational with newly rebuilt detectors and appear to be working well. All supplies have been ordered and the TGA-4000s are being tuned for the concentrations expected during the tests. We have also found a way to significantly reduce the overshoot of the TGA-4000 in response to sudden changes in tracer concentration by adjusting the electronics. (Roger.Carter@noaa.gov)

VTMX-URBAN 2000

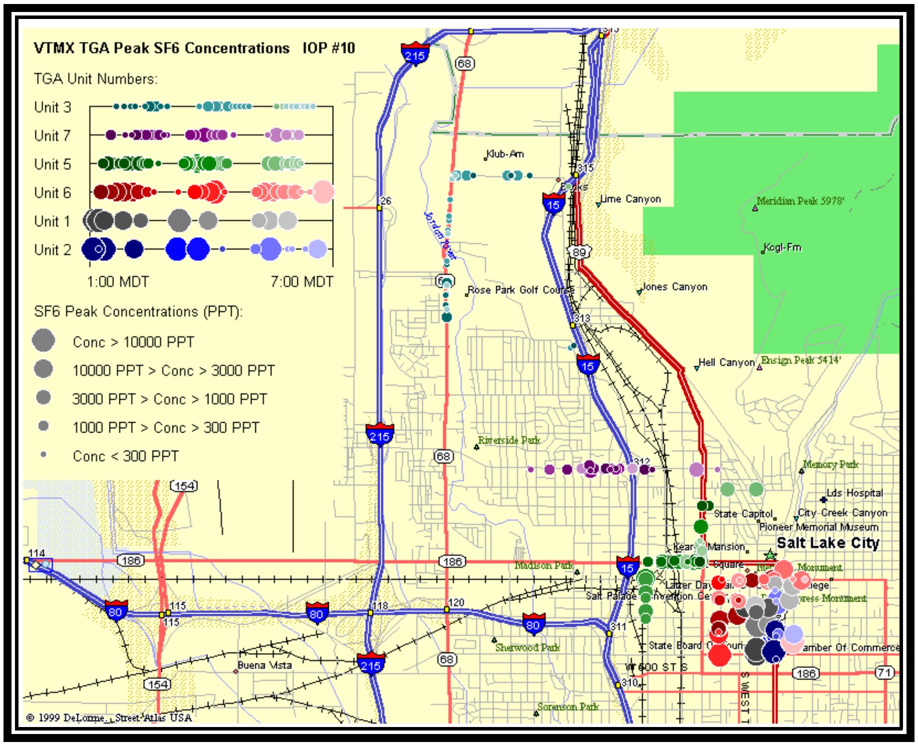

Figure 5. Map of Salt Lake City, UT, showing locations of peak SF_6 concentrations measured by 6 realtime analyzers during IOP 10.

Analysis work has begun on the mobile SF_6 analyzer data. Six realtime SF_6 analyzers were simultaneously deployed for six tests (IOP's) conducted in Salt Lake City in October, 2000. Four analyzers were mobile, and placed at distances of 1, 2, 4, and 6 km from the downtown release point. Two other units were stationary, and were deployed near the release point to monitor plume temporal variability. Plots of the kind shown in Figure 5 were generated to show the locations of the peak concentrations of each pass through the plume and to indicate the time of the plume crossing. The dot size indicates the SF_6 concentration, while the hue (dark to light) indicates the passage of time. As can be seen in the accompanying figure, the location of maximum concentration was quite variable as evidenced by the considerable meander observed in the nocturnal winds. (Kirk.Clawson@noaa.gov, Neil Hukari, Roger Carter)

Cooperative Research with INEEL

INEEL Emergency Operations Center (EOC) Support

The first EOC drill of the year took place during February. It dealt with a simulated terrorist incident at INEEL and included a possible atmospheric release from the RWMC complex at INEEL. Two FRD staff members responded to the drill. (Richard.Eckman@noaa.gov, Debbie Lacroix)

INEEL Mesoscale Meteorological Network

At the request of INEEL, joint frequency distributions (JFDs) were computed for nine towers in the Mesonet using data from calendar year 2000. These JFDs are a function of wind direction, wind speed, and Pasquill-Gifford stability class. Some of the algorithms used in computing the JFDs in prior years were modified for the 2000 data. The most significant change was in the computation of the hour-average standard deviation σ_θ of the wind direction. The old algorithm tended to underestimate the hour-average values. The new algorithm is based on published EPA guidelines for computing σ_θ. On average, it produces σ_θ values that are about 20% larger than the old algorithm. Overall, the algorithm changes tend to increase the frequency of stability classes A-C and decrease the frequency of class F. (Richard.Eckman@noaa.gov)

Telephone Line Blues

We received a request from the INEEL Construction Storm Water Coordinator to verify that the automatic storm event notification system was operational and ready for this spring. The system monitors precipitation at the Radioactive Waste Management Complex on the INEEL. If a qualifying precipitation event happens, the person on call is automatically paged so that they can perform EPA required sampling of the runoff. Unfortunately, the telephone line used to send the pages has been down for about two weeks, despite repeated calls to the telephone repair office. We have made the system operational by switching to another telephone line (borrowed from the fax machine) until we can convince the repairman to pay us a visit. (Roger.Carter@noaa.gov)

Lightning detection support

The INEEL Emergency Planning group has been asked by the local DOE office to look into better ways to monitor lightning activity around the INEEL. They have asked FRD for assistance. We will be discussing with them ways to improve lightning monitoring within the current budget constraints. Possibilities include better utilization of existing Electric Field Mills and improvements in existing low cost lightning detectors. (Roger.Carter@noaa.gov)

INEEL Pollutant Transport and Diffusion

Within the past couple of years, an environmental group in Jackson, Wyoming, has started accusing INEEL of releasing radiological and chemical contaminants that are being transported to Northwestern Wyoming and harming the environment. The air monitoring performed by INEEL and the State of Idaho within the Snake River Plain shows no indications of such harmful pollutant transport, but INEEL has offered to add an additional air monitoring station in Jackson. A meeting is scheduled in early March with county commissioners in Jackson to discuss the proposed station. INEEL has asked FRD to provide guidance on the meteorological aspects of the controversy. This includes such issues as the expected transport direction of pollutants released from INEEL, the degree of plume dilution that can be expected at the distance Jackson is from INEEL, and the effects of meteorological conditions and mountainous topography on plume transport and diffusion. Meetings were held with DOE and INEEL personnel in late February to discuss these issues. A staff member from FRD will also attend the Jackson meeting in March. (Richard.Eckman@noaa.gov, Kirk Clawson)

INEEL Mesoscale Modeling

In February, some capability was added to compute and display air-parcel trajectories using output from the FRD MM5 model runs. This effort was partly in response to the Jackson, Wyoming, controversy mentioned elsewhere in this report. The FRD display system can now compute and show forward trajectories for air parcels initially located at INEEL. Backward trajectories can also be computed for specified locations. These backward trajectories can be used, for example, to investigate the paths that air takes in reaching Jackson according to the model simulations. (Richard.Eckman@noaa.gov)

Papers

Carter, R. G., and R. Ridenour, 2000: An improved short term transport and dispersion forecasting method. *Radiation Protection Management*, **17(4)**, 26-37.